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RESEARCH[1]

MAN'S search for information about his surroundings and about himself is as old as the race. He has been conscious of it since thought began. Only in degree, in precision, has our search changed in all the ages; now, in designating a very careful, very logical, extremely critical phase of this feature of our intellectual life we have come to use the word research.

A dog searches for a bone led by his senses and experience, influenced little, if at all, by what he has of reasoning ability. The morphologist searches for the reasons underlying the shape of the bone; the physiologist examines into its functions—both search with the aid of their highly developed reasoning powers, and their work we call research.

Whatever the details of the special case, research is a mental process superimposed upon the observation of facts. It is mechanical as well as rational, the two functions being equally important. Because it is a human activity it may be judged in terms of its usefulness as against its cost, cost being interpreted as human effort rather than as mere money expended. However, being wide enough to embrace the infinite multitude of observable facts, whether these are found under natural conditions or as the result of the artificial conditions we call experiment, and also being a product of the trained imagination whose every guess is legitimate if in harmony with the facts, research is not easily reduced to analysis. How is it possible to place a value on a product as intangible as a work of art? How can we say whether the effort that went to the making of it is justified or wasted? It is no easier to judge the value of the products of the play of the imagination on the facts of existence. It is perhaps still harder to judge the value of the effort that goes to the collection of a mass of minute facts, each trivial as the hammering of a nail into a plank, yet each contributing to knowledge. It is much easier to judge of visible products, thus, when the architect and the artisan are finished, the result of the interplay of imagination and detail stands before us and we can judge it according to our likes and dislikes, of our feeling of its fitness to fulfill its purpose as measured against its cost.

Because of its illusiveness, because of the enormous prizes it has brought to mankind, because of its value

[1] Presented at a joint meeting of the Rhode Island Sections of the American Chemical Society and the American Association of Textile Chemists and Colorists.

as a mental training, there is a tendency to be slipshod in criticizing research. Research is such an honest effort to achieve something of value that we are apt to condone the futility because of the good intention, or we may err the other way and condemn what is intangible because we can not measure its use.

I propose to you that together we examine the modes and the cost of research and see if we can not reach some conclusion regarding the enterprise as a function of human society. Research for our purpose is organized effort to acquire knowledge regarding natural phenomena. If we consider the research going forward in this country, we can divide it roughly into four groups; that carried out as a part of the intellectual program of institutes of learning, which we may call academic research simply because of its home, not because of its character. Next we may place together the activities of institutions founded especially to advance our knowledge by research. The work done in the industries we shall take for our third group and, finally, we shall make a fourth classification which we shall call professional research.

In all this work the effort can be classified in this way: materials and energy used, which includes the cost of the surroundings in which the research is carried out, of the equipment and of the energy consumed in the shape of heat, light and power. The man power—this involves not only the thinking brain conducting the research, but also the manipulative functions of the research man or those assisting him in the research. This would include what the industrialist calls executive overhead as well as labor assistants. Time, as a function of research, is really important, especially in the industrial field and should be considered in connection with all research.

Academic research has been the fountain from which the most important knowledge regarding our surroundings has come. There was a time when research was unknown outside the walls of the institute of learning or the private home of the learned man. Now-a-days the quantity of academic work is greater than ever before, and I think that we are not critical enough of it. Let us consider first of all the cost of research, which is obviously the most easily measured factor. In industry, where the cost of doing anything is checked very closely, it has been found that a trained research man whose salary is about $300 per month requires materials and man-power assistants costing $450 per month at least. That is to say, the research cost per hour, assuming a 200-hour month, is $4.00. The work done in the university costs less because, in view of the fact that the student doing his research gains by learning how he should approach a problem, he is paid nothing for the time he puts in, although he may work his way through by teaching part time for which he is paid. Assuming, and I think this is not assuming too much, that the incidentals cost just as much in academic work as they do in the industries, that is, the working space properly furnished, heated and lighted, the laboratory facilities, the administrative expenses, the time of the man assisting the student, we reach a figure of approximately $2.25 per hour, plus the effort of the worker. If a doctor's thesis takes 2 years of 9 months a year and the research occupies the candidate 8 hours a day during the academic year, then we reach a figure of $6,480 as the cost of a doctor's thesis. Multiply this by the number of researches of this kind being carried out and we find that the people of the country are spending millions of dollars on academic research of this type alone. Any industrial firm spending such an enormous sum would be highly critical of the results obtained.

I suggest that academic research is not properly scrutinized. We regard it so much as one of the steps in the course perfecting a student that we are apt to ignore its intrinsic value. Now I am not going to argue that the training the student gets is not of primary consideration, although I think that it is less important than it is sometimes thought. I am also willing to concede that the student is doing his first research work and is therefore much less competent than the older research worker of the industry, yet when everything is taken into account it seems to me that we could get very much more from the work than we do.

A destructive criticism is easy. On the constructive side I suggest that research problems can only be chosen by men who have a research instinct; by men who are following up a lead which may mean a real advance in our knowledge. Such men are rare and therefore my first change would be in limiting the number of academic institutions in which research is done for advanced degrees. This calls for a great unselfishness, while I am afraid that inevitably selfishness is characteristic of the attitude of the academic body to its students, perhaps unconscious, but arising out of the situation. Thus if a senior has shown great promise it is natural for the graduate school to try to keep him when they should send him to another university where he will find the man best able to lead him on in the lines which he has chosen. Of course, if the graduate school of his own university can conscientiously hold him because they believe they can give him the best that there is in the country, then they are justified in doing so, but they should be extremely critical.

In furthering this improvement I should like to

see the undergraduates acquire some critical faculty of their own, just as they do in Europe. This, I believe, can be brought about only by getting away from the idea that the university is merely a finishing up of an ordinary education and by adopting the European belief that it is a great advantage to move from one university to another, which can be done there without loss of effort. In that way the student encounters different presentations of the same subject, and he learns to acquire a certain discrimination which seems totally lacking in the student's attitude to research in this country. When it comes time for him to do his doctor's work, he should be quite clear in mind that such and such a university, because of the research ability of the professor in charge of a single branch, is the only place in the country for him to go. Since he can work his way about as easily in one place as another, there seems no reason why we should not be able to foster this procedure.

I should like to see a definite stand taken against the point of view that because a conscientious young instructor has been promoted on account of his teaching ability to an assistant professorship, he is therefore entitled to experiment on graduate students. Unless the young man has, by his own work, established the intrinsic merit of his attitude to research and his capacity for initiating research, he should not be allowed to act without the advice and direction of a maturer research man. On the other hand, it should be recognized much more quickly than is often the case when the young man is a more brilliant research man than the head of the department, and then the head of the department should be honest enough to turn over his best students to the assistant professor.

From my experience of industry and of academic research, I do not believe it possible for a man to function at the same time both as an executive of a large establishment, as a teacher and as a director of research. I do not believe it can be done, except by a great sacrifice of the highest attribute of the man, that most delicately balanced function of the mind which is the guiding spirit of research. Therefore, I should like to reiterate what has been said so often, both by myself and others, that we should not reward research by executive responsibility and that we should relieve the true research man from the round of ordinary teaching and let him build up a research school fed by students from the countrywide, sent by his colleagues and the well-informed opinion of the student body.

I know that we argue for the complete independence of the research man and yet I should like to see a more collective effort made to unify the research effort of the country. A young teacher, having carried out a small research problem which may have been a very secondary feature of a larger problem given him by his research master, starts in to do research for himself. His mind is led, very naturally, to some little detail arising from the work he has done. That is good for him, but his view is too narrow and he is quite remarkable if he does not overestimate what is really quite trivial. If we carried our national effort further and placed before our research men problems which might appear worth attacking because of their relation to still larger problems of importance in the opinion of the great research men in the field, I believe that these men would be tolerant enough to avoid the danger of stifling a new line thought out by a young man and yet we should have the advantage of far less wasted effort than we have at present, because I think we stretch much too far our sympathy with the piece of research which is just one more little pebble in the palace of knowledge. We are too apt to encourage the collection of pebbles to put around the flower borders and grounds instead of hewn stone to build into new wings.

Even assuming an excellent subject for a doctor's thesis it still may remain true that there is a waste. In industrial work the importance of time is stressed constantly, perhaps it is over-emphasized. In academic work we have accepted the doctrine that accuracy is so much in danger of being sacrificed if an effort is made to speed up the work that we lean the other way. I think we should remember that the real leaders of research, while they may have taken a great deal of time before they felt their results sure enough to present them to their colleagues, did actually work very fast in getting the evidence together. I remember that when his friends urged my old teacher Wislicenus to hurry up his publications for fear of losing his priority, he paid no attention whatsoever but went along gathering the data necessary. At last he would publish and his paper would, perhaps, fill a whole volume of the *Annalen*. His contribution was so finished, was so profound, that the matter of priority ceased to bother anybody, but from this it would be quite unfair to argue that he wasted time. Actually he worked very rapidly and proceeded from step to step with a certainty that was most economical of effort.

Of course the young research man on his first problem is bound to waste a lot of time, but let us show him how to economize his effort and let us, above all things, point out to him that his loss of time is something which marks his immaturity rather than being the proper attitude toward the work he is doing. A young man may be able to observe only one reaction at a time, whereas a man with experience and a

higher critical faculty may undertake six parallel experiments with success, but let the young man do as much as possible and do not encourage him to think that it is the essence of research to watch the pot boil. In this connection I think that it would be wisdom to devote a little more of the money available for research work to amplifying the apparatus available and to furnishing manual help so that dish washing might not be a necessary part of the research worker's time consumption. I always remember the contrast that was presented in the attack on water analysis by the regular class in this subject at one of the universities at which I taught and by the government analyst on the same work. The students carried out about two complete analyses in a semester, giving six hours a week of laboratory time to it. The expert carried out, as I remember it, something between 10 and 15 analyses in parallel and was busy every instant of the time. It would be impossible to expect such a high technique from students, but it is reasonable to demand the best they can give.

In substance, then, my criticism of academic research is that it fails of being what it should, because the subjects chosen are not well selected, the time spent is out of all proportion to the results, and the effort is not sufficiently coordinate.

My criticism I want to be taken as constructive, because I am, in reality, thoroughly in accord with the belief that academic research is fundamental to the success of the race. It is on this account that I am glad to think that owing to the realization by those directly engaged in industry of the importance of the work done by their own research men, we shall see eventually a very great encouragement of basic research by men of wealth. Already these men have found it possible to express their interest by giving magnificent laboratories, but they have not yet found a means of doing that which they realize is still more important, fostering the man of genius. Obviously, it would only be the part of stupidity to feel that magnificent walls are a more permanent contribution and a fitter monument than a share in deeply significant work. The rich man knows well that were he to succeed in raising the status of the scientist he would be wonderfully rewarded. At present there is no very obvious way of doing this. Unquestionably our great research men should be able to look forward to earning salaries of $25,000 and over. We must admit that our society is built up on success as measured in terms of money, and therefore a great man should have the satisfaction of independence, together with the stimulation of feeling that society has awarded him a position of success.

It is true that industrial scientists are not paid any such munificent salaries, yet they are placed in a position to participate in industrial success to an extent unknown in academic circles. If a university were making 25 per cent. clear on its investment and the merit of this financial success were traced in large part to special men on the teaching staff whose outstanding genius drew the large student body, it would be only fair to share the profit with them to some extent. Actually this is practically what was done in Germany and it has resulted in the social status of the professor being all that he could ask and has made him relatively rich. It also introduced the factor of competition among professors, which is most excellent though practically unknown in this country. How can we make it possible that our great scientists should realize such success? I do not believe in tying up large endowments with particular chairs, because frequently the surroundings may be such that they prevent the best man available from being secured or the move essential to accepting the new chair may tear him from friendly surroundings which contribute largely to his success as a scientist. Again I say I do believe in extremely handsome salaries as a reward of enlarging the domain of our basic knowledge and this irrespective of the apparent utility of the discoveries. Surely we may count on enlightened response to this problem by the wealthy who have before them the admirable example set by Nobel, who, you will remember, stipulated that his prizes should not be awarded were there no worthy recipient found.

INDUSTRIAL RESEARCH

Industrial research I define broadly as all research paid for by the owners of our industries, research being taken to mean anything out of the ordinary in the way of control work, as well as such utilization of basic knowledge as is necessary for greater economy in production. I am willing to call research even that type of work which is no more than intelligent works control.

Research is just as imperative to the existence of a large producing corporation as it is to the growth of science. That fact is generally recognized in this country. It is not so taken for granted, but it is no less true, that research is equally as important to the small concern. Unfortunately the small industrial unit does not feel that it can afford research. Actually the stockholders would find it a most profitable investment were they to plow back some of their profits into research. However, there is every need for caution in this matter. Usually it is true that the more isolated the research chemist the maturer he ought to be. I am a thorough believer in the genius of youth, but as an independent research

worker in surroundings which limit him strictly and force a great deal of routine upon him as well as a necessity for impressing owner-managers, the very young chemist can not compare with one of many years' experience. It follows, then, that the smaller the company the more experienced should be their chemists, but good experienced men are necessarily more expensive than young ones, and the small company on deciding to choose a research chemist usually picks one unsuited to its needs. They will pay a man $175 a month when they need the experience that makes a man worth $125 more than that. The extra salary would make the whole outlay a very much better investment if they could but be brought to see it; an investment that would carry itself easily. Another cause of trouble and unproductive expense is that a man hired to do research by directors or owners having but little knowledge of the real meaning of such work is put by them into a position calling for a great deal of routine, so much that real research is out of the question. This discourages the chemist and disappoints his employers who consider research a failure because they have had only bills to pay and can see no return.

In the case of large corporations conditions are very different. They can afford research on a very generous scale. Such research has to pay its way and to say this does not mean that directors are blind to the value of research even though there is no immediate return from it. It means that the money of the stockholders must be spent profitably under the conditions existing at the moment. It means that the research must have a direct purpose in view; it is not enough that it should extend our knowledge even though in that field of enterprise in which the industry grows.

It is evident that herein lies the very most difficult problem of the research director. In a large establishment he must delegate much of the detail to the senior men under him, but the choice of what is done must rest with him. He must decide, in cooperation with his maturest men, whether a problem should be taken up fundamentally or empirically. Often a piece of work will be productive much sooner and will cost much less if it is treated from basic principles. For example, it may be that the establishment of the relation between certain fundamental physical constants and observed results when once correlated will enable the research man to formulate a general statement covering all cases in point and enable him to go ahead much more quickly than were he to try to find the most suitable material for his purpose by trial. On the other hand, it may be very much cheaper, though essentially less satisfactory, to learn by trial. It all depends on the problem in relation to the industrial requirement. This is the very striking difference between academic and industrial research. It is one the young man, fresh from the university where he has been drilled in the importance of fundamentals, is very apt to ignore, with the consequence that he thinks ill of research done as he finds he is told to do it, he grows careless or he insists on going his own way and gets into trouble in either case.

In a sense research that can not go to fundamentals and yet must bring results is more of an art than a science. It is just on that account that it calls for a very high order of scientific training, otherwise it will degenerate into unproductive pottering, that worst curse of the research laboratory. It takes patience and a good training to carry out work with the utmost elaboration, but it takes patience, training, experience and a certain type of sagacity if a man is to use his faculties as a guide and follow the scent without stopping to make sure of anything.

I think that on the whole the work done by the industries, as far as subject-matter is concerned, is fairly satisfactory, more so, perhaps, than academic research. Every now and then we run across some absurdity carried out by a research worker who has forgotten his elementary chemistry and physics and decides to prove or disprove some fact by experiment when he should be able to reason it out with pen, paper and a text-book. I think also that on the whole industry utilizes its man power satisfactorily. I think that the rewards coming to the research worker in industry are on the whole adequate. If I have any criticism it is that the industrial concern does not reward sufficiently the acquisition of experience that is invaluable; by that I mean that the knowledge acquired by a good man, after ten years as a specialist, can not be replaced unless the firm is lucky enough to have a subordinate growing up to fill the position. Such a man should be made comfortable, should be kept satisfied, in order that he may do his best. I am sure that the employers of research men are not sufficiently alert to the importance of preventing occupational stagnation if good research is to be done. Every research man should have a chance to get away from his working surroundings and meet other scientific men at least once a year, quite without jeopardizing his vacation. He should be encouraged to develop as a man of culture as well as a specialist and on this account should he desire an extension of the two weeks' vacation in order to travel, such a request should be given sympathetic hearing. Unless a research worker is growing in all directions mentally he is not fully efficient.

Turning to the time factor I think it fair to say on the whole that the industry is apt to force research

to be more hurried than is wise, but I am rather slow to make this statement because after a considerable experience I realize that there are a great many factors other than the mere acquisition of the information which must be taken into account. Let us say that a research laboratory has developed a method on a small scale for making a product which promises to be very profitable. The directors of the company believe that by an expenditure of a million dollars and provided they can begin production in six months they can obtain a handsome return on their investment. Plans for the plant must be rushed, but plans depend, in the case of chemical plants, on the equipment to be housed and the equipment depends on the details of the process as carried out on a large scale. Naturally the research necessary to put the process into shape for large scale production is rushed to an unhealthy extent and in consequence it is not unusual to find that a good deal of the equipment has to be scrapped later. But this does not mean that the hurry was unwise. It may be that in the long run the stockholders benefit more by the speed with which the work goes forward, even counting the loss of the equipment, than they would if time were taken to put the process into excellent shape. One must remember that to do a thing perfectly from one point of view is not necessarily the best commercial procedure.

Of that work which is done in the research institutions of the country I am unable to say much because I have no direct experience. I believe that an institute like that founded by Rockefeller is one of the nation's greatest assets, largely because its contributions to medicine are international and tend to draw together the peoples of the world. As long as such institutes are in the hands of scientists of genius they will be of the utmost importance to us. They are expensive only when looked at from the narrow point of view of dollars and cents.

The professional men of this country are doing a great deal of good research. They do this by observing carefully during their contacts with conditions as they find them. They are taking the place, to some extent, of the rich amateur who at one time was the large contributor to scientific progress. The difference is that the work of these men of to-day is more directly related to the practical use of science than was the work of men like Cavendish. Work of this kind carried out by physicians may flower into research work as richly endowed as that carried out at the Mayo Foundation, which has become a center of biological chemical research.

In looking over the whole field of research in this country we should be satisfied that we are putting so much effort into so useful an endeavor. We should not, however, be satisfied with things as they are and research, like everything else, must grow, must develop, if it is to mean all that it should to us. What we should strive to bear in mind is the truth of the statement made by John Milton:

> Our greatness will appear
> Then most conspicuous, when
> great things of small,
> Useful of hurtful, prosperous of adverse,
> We can create.

R. E. ROSE

WILMINGTON, DELAWARE

A LITER AND A HALF OF BRAINS[1]

A LITER and a half is our portion: so much of it water that Hippocrates called the brain the metropolis of humidity and Sir Thomas Browne noted that, in consequence, skulls are less consumed by fire than other bones.[2] Doubtless there are other functions of the brain for us to consider than that of rescuing the skull from a fiery oblivion.

How greatly we extol ourselves above the brutes which perish. Each of us, lords of creation, maintains within his skull as much brains as would fill the heads of three gorillas. And very gravely we are told that for our bulk one third of all this mass would suffice; the rest is sheer intellect "which some suppose the soul's frail dwelling house."[3] But this is mere convention and with the times conventions change. In Aristotle's day the brain was not, as some have said, the seat of sensation and of thought: it is required rather to cool the blood and by thus tempering its heat to make sensation possible. Because man is the hottest of animals therefore he has the largest brain.[4]

> I talk of dreams,
> Which are but children of an idle brain,
> Begot of nothing but vain fantasy,
> Which is as thin of substance as the air,
> And more inconstant than the wind.[5]

But enough. Aristotle was born about 384 B. C. when Plato was already forty-three and Socrates had been dead fifteen years. The foundations of a study

[1] An address delivered at the annual banquet of the American College of Physicians, Cleveland, February 24, 1927.

[2] Sir Thomas Browne, "Hydriotaphia." D. Lloyd Roberts, ed. London, 1898, p. 277.

[3] King John, V. 7. 3.

[4] Stocks, J. L., "Aristotelianism." London and New York, 1927, p. 76.

[5] "Romeo and Juliet," I, 4, 95.

of the brain were laid by Herophilus, who was born in the closing part of the fourth century, B. C., and flourished at Alexandria during the reign of the first Ptolemy. He discovered the nerves, distinguished them from sinews and thought the brain the center of the nervous system.[6] This idea was elaborated by Galen in the second century, A. D., who attacked Aristotle's theory of the heart as seat of the sensitive soul and the source of nervous action. According to Galen sensation and movement are stopped and even the voice and breathing affected by injuries to the brain; moreover, injury to one side of the brain affects the opposite side of the body.[7]

Augustine, in the early fifth century, speaks of three cells in the brain, of which the second is the seat of memory and the third of motor activity.[8]

Costa ben Luca about 862 A. D. distinguishes between spirit and soul. The spirit is a "subtle body," unlike the soul, which is incorporeal. It passes from one cell to another and operates the vital processes of the body.[9] The clearer and more subtle this spirit is, the more readily it lends itself to intellectual processes. Hence intellectual processes are inferior in women and children and in races subjected to undue heat and cold like the Ethiopians and the Slavs. We must not smile at this conception too broadly: it is reproduced almost word for word in the great Paris discussions of last century regarding Negro brain and cranium.[10] According to Costa ben Luca the opening between the first and second cells is closed by a sort of valve, "a particle of the brain similar to a worm" (the choroid plexus). When a man recalls something to memory the valve opens and the speed with which it opens explains why some men are slow of memory and others answer a question much sooner.

In the eleventh century Constantinus Africanus amplifies Augustine's conception of the three cells and puts imagination with sensation in the first, reason in the second and memory in the third.[11] The first is hot and dry, the second cold and moist and the third cold and dry. Mania is an infection of the anterior cell and melancholia a disease of the middle one.

In the twelfth century Petrocellus tells us definitely that good and evil are distinguished in the second cell and that the soul resides in the third.[12]

In spite of Galen's teaching medieval scientists still clung to the conception of the brain being secondary to the heart. Hildegard of Bingen, who died in 1180, A. D., speaks of the attenuation of humors in the chest whereby "the phlegm is dry and toxic and ascends to the brain. There it produces headache and pain in the eyes and wasting of the marrow, and thus if the moon is defect he [the man] may develop the falling evil."[13]

Remember Jacques' joyful account of the fool he met in the forest, how

> "in his brain
> Which is as dry as the remainder biscuit
> After a voyage, he hath strange places cramm'd
> With observation, the which he vents
> In mangled forms."[14]

Adelard of Bath, "a dim and shadowy figure in the history of European learning," who according to the Pipe Roll of 1130 received four shillings and six pence from the sheriff of Wiltshire, states that it was discovered experimentally which portion of the brain is devoted to the imagination and which to reason and memory through a case in which a man was injured in the front part of the head.[15] The famous specimen in the Warren Museum is therefore antedated by some seven hundred years.

In the following century, about 1230, A. D., Bartholemew the Englishman cites Constantinus' division of mania from melancholia as diseases of first and second cells, respectively, and tells of a nobleman whom he knew, suffering from melancholia and imagining himself to be a cat, who insisted on sleeping under the bed to watch the mouse holes.[16]

And a little later, about 1292, Arnold of Villanova in the Breviary of Practice, discussing the treatment of mania, advises as a last resort that the skin be cut in the form of a cross and the skull perforated so that the noxious vapors may escape from the brain.[17] "I'll ne'er believe a madman," says the clown in Twelfth Night, "till I see his brains."[18]

In the Bodleian Library at Oxford is a small quarto parchment in a fine Italian hand, the first complete treatise on anatomy in the vernacular, written in

[6] Thorndike, L., 1923, "A History of Magic and Experimental Science," Vol I, p. 145.

[7] *Ibid.*, p. 146.

[8] *Ibid.*, p. 660.

[9] *Ibid.*, pp. 658–9.

[10] Gratiolet, P., for example, 1856, "Mémoire sur le développement de la forme du crâne de l'homme," etc. Compt. rend. de l'acad. des Sc. T. 43, pp. 428–431.

[11] Thorndike, L., Vol. I, p. 660.

[12] Thorndike, L., Vol. I, p. 735.

[13] Singer, C., 1917, "The Scientific Views and Visions of Saint Hildegard. Studies in the History and Method of Science." Vol. 1, Oxford, p. 47.

[14] "As You Like It," II, 7, 38.

[15] Thorndike, L., Vol. ii, p. 39.

[16] *Ibid.*, p. 408.

[17] *Ibid.*, p. 860.

[18] "Twelfth Night," IV, 2, 126.

1490. It is the Anothomia of Hieronymo Manfred.[19] Here is a pretty accurate description of the cerebral ventricles not greatly bettered until Leonardo made his ventricular casts.[20]

"To the side of this [the foramina of Monro] is another thing like a subterranean worm, red as blood, yet tethered by certain ligaments and nervelets. And this worm when it lengthens itself closes these passages, and thus blocks the path between the first ventricle and the second. Nature has wrought it thus, so that when a man wills he may cease from cogitation and thought; and similarly when, on the other hand, he would think and contemplate, this worm contracts itself again and opens these passages." . . .

"It will be apparent that when the back part of the head is injured, the memory immediately suffers; when the middle part is injured, the estimative and cognitive faculties suffer; and when the anterior part is injured, the faculties of common sensation and imagination suffer. And thus it is that the doctors have become aware of the location of these powers."

But why continue. Descartes and others, by gradual degrees have laid the sure foundation of modern study of the brain and we may pass lightly by this phase to explore more recent fancies in which Reserve has had her part. The philosophic conception of three primary vesicles was written into scientific anatomy by Leonardo and remains there in current descriptions. So hard does tradition die.

In recent years there have been numerous efforts to prove or disprove the hypothesis that head size is related to brain volume, in the present state of our knowledge a perilous task unless the brains are out and the man is dead.[21] People do not really like having their heads measured and if they suspect that the measurement is undertaken with a view to estimating brain volume something very like active rebellion ensues. When Professor Karl Pearson's assistants endeavored to make this determination upon Cambridge undergraduatees, the students, by playing tricks on the observers, almost brought the work to nought.[22] It reminds one of Falstaff's exclamation, "Well, if I be served such another trick, I'll have my brains ta'en out and buttered, and give them to a dog for a new year's gift."[23]

There is a common tendency to compare, or rather contrast, the average brain volumes in different classes of society. This must be done only with the greatest care; it is doubtful if it is ever a valid method, for differences of environment and nurture have a profound influence upon head size. For the comparison to be apt one must take a fairly homogeneous sample of approximately the same nurture and habits.[22]

Of one thing I am very certain, namely, that class distinction in our highly artificial and fluctuating society to-day is not the crowbar wherewith to pry open this problem of brains. And so we have tried another tool put into our hand by luck. Ever since 1913 we have kept a steady watch upon head size and brain volume of those unfortunates who, having ended their days already, terminate their corporeal existence under our care. Reserve occupies a unique position in this matter, having long enjoyed to an extraordinary degree the spirit of cooperation with the city. Dr. Hamann's statesmanship and Mr. Leonhart's tact have resulted in our acting as a kind of permanent morgue in which is represented a fair cross section of Cleveland's outmaneuvered victims in the struggle for existence.

The average brain volume for the adult white man is generally accepted as about 1,500 cc, perhaps a few cc more, probably no less. Among the diners here to-night, who may be classed as highly intellectual, the mean value is probably 1,550 cc. The average among Cleveland's social ineffectives from 1913 to 1917 was quite constantly within 10 cc of 1,480 cc. This difference made no impression upon us until in 1918 a strange thing happened. Our average fell to 1,410 cc. Now during that year none but the veriest fool was left destitute: the others were all in the army or earning good wages in civilian life. Still we were not stirred to attention. But in 1919 when, after the armistice, industrial stagnation set in and threw out of work many who had recently found jobs; and when, moreover, the disbanding army disgorged a glut of men upon a society which could not immediately absorb them, the average brain volume of our social failures rose to 1,520 cc. That looked serious to us and with great interest we read the prognosis of bankers and captains of industry regarding the future. According to prediction the situation improved in 1920 and our mean brain volume sank once more to near the pre-war level. But the feeling of satisfaction soon gave place to apprehension, for a second and much worse industrial

[19] Singer, C., 1917, "The Anothomia of Hieronymo Manfredi (1490)"—"Studies in the History and Method of Science," Vol. I, Oxford.

[20] Hopstock, H., 1921, "Leonardo as anatomist"—"Studies in the History and Method of Science," Vol. ii, Oxford.

[21] "Macbeth," III, 4, 79.

[22] Pearson, K., 1902, "On the Correlation of Intellectual Ability with the Size and Shape of the Head," Proc. Roy. Soc., Lond. Vol. 69, pp. 333–342; also 1906, "On the Relationship of Intelligence to Size and Shape of Head," *Biometrika*, Vol. 5, pp. 105 to 146.

[23] "The Merry Wives of Windsor," III, 5, 7.

depression set in, distress growing steadily more acute during the months of 1921. Then indeed we watched our steadily mounting average volume. Day by day, like obscene demons from the pit itself, we chalked up the rising score until it reached the appalling level of 1,550 cc. Here was a new class of men entering our portals and they came by a different route. Here were the men who could think for themselves, who knew and resented their fate. The pneumonia of the shiftless, the tuberculosis of the over-wearied struggler, the heart disease of the adventurer no longer acted alone as our receiving agents. Instead men shot themselves, or each other, threw themselves into the lake; poisoned themselves with morphine or raisin jack; perished of cold, listlessly lost in despair. All through that year and into the early months of 1922 the steady shuffle of feet on the doorstep of the Associated Charities swelled its monotonous dirge. Agitation was rife. Russia and Germany were pointed out as members of the community of nations who had passed that way before. And then, suddenly as it had begun, while yet the Charities were deluged with the throng, these expectant ghouls in anatomy saw the barometer of brain volume begin to fall, steadily, steadily down. Relief had come: though it was not apparent to the city we knew the end was in sight. Hope was restored again in those whose nervous system had been shattered by defeat. Never again have we seen the like. Slight fluctuations from year to year and an average somewhat above the pre-war mean have been our lot but never that alarming rise which we experienced in the year of intense depression.

Now these things sent us back to examine our data anew and we soon found that of two heads of the same size one might have as much as 200 cc of brain more than the other. It was not that we got larger heads in 1919 and 1921, but we got bigger brains among our social ineffectives. In normal times our pauper population is recruited from that flotsam and jetsam of humanity which idly drifts along the shores of these great lakes. "Here's Agamemnon, an honest fellow enough, and one that loves quails; but he has not so much brain as ear wax."[24] When, however, industrial distress overclouds the city new recruits appear, the honest industrious poor with too little margin for the rainy day, "purse and brain both empty; the brain the heavier for being too light. . . . O, the charity of a penny cord! It sums up thousands in a trice . . . your neck, sir, is pen, book and counters; so the acquittance follows."[25] Then there rush in, as if impatiently, the men who in indifferent times can do indifferent well, but owing to some frailty of their intellect are crushed down by a sudden galloping destitution. "Your hearts I'll stamp out with my horse's heels, and make a quagmire of your mingled brain."[26]

That, ladies and gentlemen, is the romance of the liter and a half. It is not the quantity but the quality that matters. It is not the quality of the whole but of the last small wine glassful. Taking mean values, 1,480 cc are needed for a fool, 1,500 cc for an honest man. And on the average a lady's cocktail saves us from inanity.

T. WINGATE TODD

HAMANN MUSEUM,
WESTERN RESERVE UNIVERSITY

[24] "Troilus and Cressida," V, 1, 58.

[25] "Cymbeline," V, 4, 166.

SCIENTIFIC EVENTS

BRITISH ROYAL COMMISSION ON MUSEUMS AND GALLERIES

THE London *Gazette* announces the appointment of a Royal Commission on Museums and Galleries, with wide terms of reference. The members of the commission are Lord D'Abernon (chairman), Mr. Evan Charteris, K.C., Sir Thomas Little Heath, Sir Lionel Earle, Sir Richard Tetley Glazebrook, Sir George Macdonald, Sir Courtauld Thomson, Sir Martin Conway, Sir Henry Miers, Sir Robert Witt and Dr. A. E. Cowley.

The terms of reference are as follows:

(1) To inquire into and report on the legal position, organization, administration, accommodation, the structural condition of the buildings, and general cost of the institutions containing the national collections situate in London and Edinburgh—namely, the British Museum and the Natural History Museum, the National Gallery and the National Gallery of British Art (Tate Gallery), the National Portrait Gallery, the Public Record Office, the Victoria and Albert Museum, the Bethnal Green Museum, the Science Museum, the Geological Museum, the Wallace Collection, the Royal Botanic Gardens, Kew, the London Museum, the Imperial War Museum, the Royal Scottish Museum, the National Galleries, Scotland, the Scottish Museum of Antiquities and the National Library, Scotland, the Record Department of the Registry House, Edinburgh.

(2) To investigate the existing conditions of the various collections and their growth in former years and to report in the case of each institution what is likely to be the growth of its collections and what the consequential increase in expenditure in the next fifty years if the present practice regulating acquisitions remain unaltered.

(3) To consider in what way, if any, expenditure may be limited without crippling the educational and general usefulness of the institutions, and in particular, having regard to the financial condition of the country, whether

[26] "I King Henry VI," I, 4, 109.

it would be desirable to institute a more general system of admission fees.

(4) To inquire to what extent there is congestion in museums and galleries and to report whether, if there be such congestion, it can be relieved in any other way than by extensive building and in particular whether improvement could be brought about by a redistribution of specimens between different state-supported institutions or by disposal of specimens which may be either of slight importance or in excess of requirements, by way of sale or of gift or loan to provincial museums and galleries and to other authorities; and in this connection to ascertain the practice followed in the case of the chief national collections abroad.

(5) To consider whether it is desirable to effect any change in the existing practice of the British Museum with regard to its reception and preservation of publications under the provisions of the Copyright Acts.

(6) To consider whether the existing administrative responsibility for the various institutions is the most appropriate under modern conditions and whether it conduces to the most advantageous distribution and display of the national treasures, and to report whether it would be desirable, while preserving certain defined powers to their trustees or directors, to place them all under some central authority or under different authorities than those at present controlling them.

(7) To report whether the most suitable and scientific arrangement of specimens and their allocation to the most appropriate museum or gallery are in any way hampered by the terms of benefactors' bequests, and, if so, whether it would be expedient to take steps with a view to a modification of the terms of such bequests.

(8) To make recommendations generally which may suggest themselves as pertinent in the light of the information obtained during the course of the inquiry.

EXCURSION OF THE ELECTROCHEMISTS

THE American Electrochemical Society will board a special train at Chicago on September 4, traveling as far as Seattle and Vancouver and returning to Chicago on September 21. All the important electrolytic plants, research and university laboratories and power developments *en route* will be visited. Stops will be made at the following towns: Minneapolis, Butte, Anaconda, Wallace, Kellogg, Spokane, Seattle, Vancouver, Trail, Shelby, Great Falls and Keokuk.

America is leading the world in the production of electrolytic zinc, electrolytic lead and electrolytic copper, and ample opportunities will be offered to see the very latest production of the pure metals, starting from the mineral.

Power development in the Northwest has been progressing on a very elaborate scale, and the electrochemists are interested in new centers for the establishment of various electrolytic industries.

There will be three scientific sessions held *en route;* one at Minneapolis, another at Vancouver and a third at Keokuk. The papers' program includes a wide diversity of subjects, ranging from the electrodeposition of rubber to thin film rectifiers.

A large number of members and guests have made reservations for the trip. The total cost, including berth and meals, starting from and returning to Chicago, is estimated at $182. Further details are obtainable at the offices of the American Electrochemical Society, Columbia University, New York City.

THE HERMAN FRASCH FOUNDATION FOR CHEMICAL RESEARCH

BY a decision of the Court of Appeals, a bequest of the residuary estate of Mrs. Elizabeth Blee Frasch, widow of Herman Frasch, for many years president of the Union Sulphur Company, which directed that the income of the gift of $1,000,000 was to be used for chemical research in the field of agricultural chemistry, is upheld.

The will of Mrs. Frasch left her residuary estate, received largely from her husband, who was a well-known chemist, to the United States Trust Company to establish the Herman Frasch Foundation for Chemical Research. She directed that the income be paid to one or more incorporated institutions in the United States, to be selected by the trust company, after consulting with the American Chemical Society, "upon condition that the said institution shall agree that the money so received shall be devoted to research in the field of agricultural chemistry with the object of attaining results which shall be of practical benefit to the agricultural development of the United States."

Mrs. Frasch directed that the institution so selected should have the use of the funds for five years after her death, and that before the end of this period the trustee should request the American Chemical Society to examine the work done by the institutions and report "whether in its opinion satisfactory progress has been made with the funds of the foundation toward the attainment of such practical results." If the society reported that satisfactory progress had not been made, payments would cease, and another institution would be selected to make use of the income for five years, after which another inquiry would be made.

The bequest was contested on the ground that by the terms of the will the income might be used for private research which would deprive the gift of its charitable purpose. Judge Lehman in his opinion said that although Mrs. Frasch undoubtedly intended to create a trust "for purposes which would advance the public welfare," such intention "is not sufficient to give validity to a perpetual trust for the benefit of indefinite and uncertain persons" unless authorized by a law of 1893, now a section of the Personal Property Law of New York, based on the Statute of Elizabeth, which applies to a gift for religious, educational,

charitable or benevolent uses. The court pointed out that the statute does not provide for the legality of bequests given for research work, but said:

Research is the method used by modern universities and scientific foundations to increase the sum of human knowledge. Research conducted for such purpose and by such institutions is clearly "educational" and "benevolent" within the meaning of the statute. Not every charitable, educational or benevolent use is enumerated in the Statute of Elizabeth, although that statute was intended to limit the trusts for charitable uses, which might be enforced by a court of equity. Conceptions of public charity, benevolence and education change with passing generations.

ORGANIZATION OF THE ROCKEFELLER FOUNDATION

THE following are the members and officers of the Rockefeller Foundation for 1927 under a new plan of organization:

Members: John G. Agar, John W. Davis, David L. Edsall, Simon Flexner, Raymond B. Fosdick, Herbert S. Hadley, Charles E. Hughes, Vernon Kellogg, John D. Rockefeller, Jr., Wickliffe Rose, Julius Rosenwald, Martin A. Ryerson, Frederick Strauss, George E. Vincent, George H. Whipple, William Allen White, Ray Lyman Wilbur.

Officers: John D. Rockefeller, Jr., Chairman of Board of Trustees; George E. Vincent, President; Edwin R. Embree, Vice-President in New York office; Roger S. Greene, Vice-President in the Far East; Selskar M. Gunn, Vice-President in Europe; Frederick F. Russell, M.D., Director International Health Division; Richard M. Pearce, M.D., Director Division of Medical Education; Norma S. Thompson, Secretary; Louis G. Myers, Treasurer; George J. Beal, Comptroller.

Executive Committee: The President, Chairman; John G. Agar, Simon Flexner, Raymond B. Fosdick, Vernon Kellogg, Wickliffe Rose, Frederick Strauss, Norma S. Thompson, Secretary.

International Health Division: The President, Chairman; Simon Flexner, Vernon Kellogg, Wickliffe Rose, William Allen White.

Division of Medical Education: The President, Chairman; David L. Edsall, Frederick Strauss, George H. Whipple, Ray Lyman Wilbur.

Finance Committee: John D. Rockefeller, Jr., Chairman; Raymond B. Fosdick, Frederick Strauss.

The Foundation holds regular meetings in February and November. The executive committee holds monthly meetings.

SCIENTIFIC NOTES AND NEWS

THE Osiris Prize for science amounting to $4,000, which is bestowed every five years by a committee representing five academies, has been awarded to Dr. Charles Nicolle, director of the Pasteur Institute in Tunis, for his researches on exanthematous typhus and recurrent fever and their mode of transmission by parasites; also for his researches on serotherapy in measles and scarlet fever, especially the injection of convalescents' serum.

THE Royal Society of Edinburgh has elected as honorary British fellows: Sir William Bragg, Sir David Bruce, Sir J. B. Farmer and Sir F. G. Hopkins. Foreign honorary fellows have been elected as follows: Niels Bohr, professor of physics, University of Copenhagen; Jules Bordet, professor of bacteriology, University of Brussels; Albert Einstein, professor of mathematical physics, University of Berlin; Hans Horst Meyer, emeritus professor of pharmacology, University of Vienna; Johannes Schmidt, Carlsberg Laboratory, Copenhagen, and Richard Willstätter, professor of chemistry, University of Munich.

THE commission for a portrait of Sir Berkeley Moynihan, president of the Royal College of Surgeons, has been placed by the Moynihan Portrait Fund Committee with Mr. Richard Jack, R. A., who has also been given a commission for a replica.

PROFESSOR EDWARD SKINNER KING, of the Harvard College Observatory, was granted the honorary degree of doctor of science by Hamilton College, at its recent commencement exercises.

DR. GUY L. NOYES, dean of the school of medicine and director of the University Hospitals, of the University of Missouri, was the guest of honor at a luncheon in Boston recently, given by the University of Missouri men who are finishing their course in medicine in Harvard University.

DR. CASSIUS J. KEYSER, who has been connected with the mathematical department of Columbia University since 1896, when he was awarded the degree of A.M., since 1904 Adrain professor of mathematics, has become professor emeritus.

PROFESSOR J. A. MACWILLIAM has retired from the chair of physiology in the University of Aberdeen which he has filled for a period of forty-one years.

AT a recent meeting of the British Institution of Electrical Engineers, Mr. A. Page was elected president and Captain J. M. Donaldson, vice-president, to take office on September 30.

DR. K. NAKAMURA, president of the Tokyo Higher Technical School and for a number of years head of its department of electrical engineering, was recently elected president of the Japanese Institute of Electrical Engineers.

DR. MASUJIRO NISHIBE, of the laboratory for infec-

tious diseases of the Japan government, and Dr. Shoji Nishio, of the Keio University Medical School, Japan, have received fellowships under the Rockefeller Foundation for the year 1927, and will pursue their studies in the United States.

W. W. SARGEANT, who has been secretary of the board of trustees of the California Academy of Sciences since 1913, has resigned in order that he may spend some years in Europe. Miss Susie M. Peers, who has been secretary to the director of the museum of the academy since 1915, has been appointed secretary to the board.

DR. ROGER C. WELLS, of the U. S. Geological Survey, has accepted appointment as associate editor of the Washington Academy of Sciences to represent the Chemical Society.

G. BERNARD HELMRICH, who has been connected with the engineering faculty of the University of Oklahoma for the last ten years, has rejoined the Detroit Edison Company in the capacity of designing engineer.

E. C. LARUE, head of the Pasadena branch of the U. S. Geological Survey, has resigned after twenty-three years of service. According to the technical journals, the reason assigned was that the government had prohibited him from advocating his opinions and beliefs with reference to the Colorado River. Mr. LaRue is a recognized authority on the Colorado River and its water problems and was called to Washington before the congressional committee investigating the Colorado River following attacks on the Boulder Canyon project, which he styled as extravagant and not as practical as others which he outlined.

DR. EDWARD R. WEIDLEIN, director of the Mellon Institute of Industrial Research of the University of Pittsburgh and president of the American Institute of Chemical Engineers, will spend September and October in visits to European educational institutions, research laboratories and chemical works.

DR. WILLIAM H. EYSTER, professor of botany at Bucknell University, Lewisburg, Pa., is sailing on August 20 for Germany, where he will spend twelve months as a fellow on the John Simon Guggenheim Memorial Foundation. His address will be Pflanzenphysiologisches Institut der Universität, Berlin-Dahlem, Germany.

DR. DAVID FAIRCHILD, senior agricultural explorer of the U. S. Department of Agriculture, and his associates, after a voyage to the Canaries and West Africa, including Senegal, Gambia, French Guinea, Gold Coast, Sierra Leone, Nigeria and Fernando Po, has returned to the United States on the motor yacht *Otowana,* owned by Mr. Allison V. Armour.

ELLSWORTH P. KILLIP, of the National Museum, has returned from a botanical trip to the Eastern Cordillera of Colombia. The party, consisting of Mr. Killip and Albert C. Smith, of New York, was sent by the National Museum, the New York Botanical Garden, the Gray Herbarium of Harvard University, and the Arnold Arboretum to obtain botanical specimens in the little-known region between Bucaramanga and the Venezuelan border.

DR. N. H. DARTON, of the U. S. Geological Survey, has returned from Central Venezuela where he has been making geologic reconnaissance surveys for an oil company during the past six months.

DR. FREDERICK STARR, associate professor emeritus of anthropology at the University of Chicago, who has returned from Japan, gave on August 2 a lecture at the university on life in that archipelago.

DR. AIHIKO SATA, formerly president of the Osaka Medical College in Japan, left in May for a lecture tour through Germany as exchange professor at the University of Berlin; his lectures will be on immunization of tuberculosis.

A COMMEMORATION in celebration of Lord Lister's centenary was held in Edinburgh on July 20, at the time of the meeting of the British Medical Association. The Earl of Balfour presided and addresses were delivered by Sir William Watson Cheyne, Professor Tuffier, Paris; Professor Harvey Cushing, Harvard University, and Professor John Stewart, Halifax, Nova Scotia.

CAESAR AUGUSTINE GRASSELLI, chairman of the board of the Grasselli Chemical Company, died on July 28, aged seventy-seven years.

RALPH LUSK, instructor in the department of geology at Harvard University, has died suddenly at the age of thirty years.

J. H. PAARMANN, curator of the Davenport Academy of Sciences (now the Davenport Public Museum) since 1902, died on July 14. He was born September 2, 1870, and received his academic degrees from the State University of Iowa.

SIR HARRY JOHNSTON, the well-known explorer, naturalist and author, died in London on July 31, aged sixty-nine years.

PROFESSOR A. KOSSEL, emeritus professor of physiology in the University of Heidelberg and editor of the *Zeitschrift für physiologische Chemie,* who was Nobel laureate for physiology in 1910, died on July 6, aged seventy-three years.

DR. GUSTAV FRITSCH, professor of anatomy and physiology in the University of Berlin, has died at the age of eighty-nine years.

DR. KARL BALDUS, assistant of the zoological institute of the University of Heidelberg, died on June 26. Dr. Baldus published important contributions concerning the histology and physiology of the brain and the function of the eyes in dragon-flies.

Popular Astronomy reports that Professor Vincenzo Cerulli, the Italian astronomer, vice-president of the International Astronomical Union and of the Astronomische Gesellschaft, president of the Societa Astronomica Italiana, honorary professor of astronomy at the University of Rome, died suddenly on May 30, at Merate (near Milan), during the inaugural ceremony of the new observatory. Professor Cerulli was born at Teramo (Abruzzi) on April 20, 1859.

CIVIL service examinations are announced as follows: For vacancies in the Bureau of Chemistry and Soils, at a salary of $3,000 a year, applications to be received not later than August 9; for associate biochemist in the Bureau of Plant Industry, at a salary of $3,000 to $3,600, applications to be received by August 16, and for physicist in the Berkeley, Calif., office of the Bureau of Chemistry, at a salary of $3,800, applications to be received by August 31.

BY the will of the late Charles Fuller Baker, dean of the College of Agriculture of the University of the Philippines, his zoological collection, comprising more than 50,000 specimens, has been given to the Smithsonian Institution, and collections of less extent to the universities of Berlin, London, Madrid, Paris, Moscow and Vienna.

THE meeting of the International Congress of Physicists will take place at Como, the birthplace of Allessandro Volta. A special celebration in connection with the meeting has been arranged for September 8.

THE American Mathematical Society, the Mathematical Association of America and the American Astronomical Society will hold their meetings at the University of Wisconsin during the week of September 5 to 10.

THE Second National Symposium on General Organic Chemistry will be held at Ohio State University, Columbus, on December 29 and 31. The headquarters will be at the Neil House. Suggestions for the program should be sent to the secretary of the division of organic chemistry of the American Chemical Society, Professor Frank C. Whitmore, Northwestern University, Evanston, Illinois.

THE annual Pacific Coast convention of the American Institute of Electrical Engineers will be held at Del Monte, Calif., from September 13 to 16. This is one of the three annual national conventions of the institute. The first day (Tuesday) will be given over to the registration and sessions of delegates from the various student branches. The student conference will be in charge of R. W. Sorensen, professor of electrical engineering at the California Institute of Technology, Pasadena. On Wednesday, Thursday and Friday mornings and Thursday afternoon there will be technical sessions. On Wednesday evening President Gherardi will preside over a general meeting to be addressed by Dr. Harris J. Ryan on "Phases of Future Electrical Development." The banquet will be held Thursday evening. Wednesday and Friday afternoons and Saturday will be open for recreation and trips.

AN Institute of Cooperation, in which speakers of national prominence in the field of agricultural cooperation will participate, is to be held at Storrs, Conn., from August 16 to 19, under the auspices of the Connecticut Agricultural College. Dr. E. G. Nourse, formerly professor of agricultural economics at Iowa State College and now chief of the agricultural division of the Institute of Economics, Washington, D. C., and Dr. J. T. Horner, of the Michigan Agricultural College, an authority on milk marketing, are scheduled to address the institute. J. W. Jones, division of cooperative marketing, Bureau of Agricultural Economics of this department, will discuss tobacco marketing. Professor A. E. Cance, of Massachusetts Agricultural College; Dr. R. B. Corbett, of Rhode Island State College, and F. V. Waugh, of the Massachusetts Bureau of Markets, are also on the program. Though arranged primarily for directors, officers and managers of cooperatives, the institute is open to all who are interested in the cooperative marketing of farm products or the buying of farm supplies.

The British Medical Journal states that on the occasion of the centenary of the Faculty of Medicine of the Egyptian University, Cairo, the Egyptian government has decided to organize a medical congress in Cairo, to deal especially with tropical medicine and hygiene. The congress will take place in the winter of 1928, probably in November or December. The constitution of the organization committee will shortly be announced officially. It is understood that invitations will be sent to universities and institutions particularly interested in tropical medicine and hygiene and their branches.

A BILL has been passed by the Egyptian Parliament, according to which there will be created a Ministry of Public Health of the national government. Previously the supervision of public health work was under the Ministry of the Interior. The rapid growth of government health work, particularly in the country dis-

tricts, has made necessary the creation of the new executive department. A minister has not as yet been named for the new position. In creating the new ministry, parliament appropriated about $5,000,000 to cover its budget during the fiscal year 1927–1928.

CONSTRUCTION of a special hospital for the School of Tropical Medicine at Porto Rico was begun on June 1. The hospital will occupy a site adjoining that of the laboratory building of the school, and will contain forty-five beds and an out-patient department. The cost of the building and equipment will be approximately $130,000.

THE Legislature of Hawaii has again appropriated the sum of fifteen thousand dollars for the work of the Pan-Pacific Union, this being the amount recommended by the Governor of the Territory and the usual appropriation made by the Hawaiian Legislature. Besides this about twenty thousand dollars a year is given annually by friends of the Pan-Pacific Union in Hawaii for its support, besides occasional appropriations from governments of Pacific countries. Each country supports its own Pan-Pacific organizations and sends delegates to the conferences called by the Pan-Pacific Union. In June, 1928, there will be a Pan-Pacific Women's Conference held in Honolulu. In July, 1928, a second Pan-Pacific Commercial Conference in Los Angeles. In July, 1928, a Pan-Pacific Medical Conference in Honolulu, with several smaller conferences of scientists as guests of the Pan-Pacific Research Institution.

THE *Journal* of the American Medical Association reports that about 135 scientific men and physicians attended the recent dedication, sponsored by the Zoological Society of San Diego, of the Zoological Hospital and Research Institute, San Diego, which is a gift of Miss Ellen C. Scripps. Physicians interested in research are invited to avail themselves of its facilities, no charge being made except for material used or broken. The building is located in a large zoological garden. It will be a hospital for animals in the garden, and pathologic tissues from zoological gardens throughout the country will be collected for a study of animal diseases. Physicians, research workers and students in biology will find here the necessary equipment for carrying on research. There are eleven small laboratories, each equipped for special work, a roentgen-ray and darkroom, a library, general laboratory, technician's laboratory offices and morgue and a photomicrographic outfit. The plan is to afford college professors and advanced students an opportunity to continue studies when in California, and to attract biologists interested in avian and mammalian research, as do some noted marine biologic stations. Further information will be given on request to the hospital, Balboa Park, San Diego. Dr. Rawson J. Pickard is chairman of the hospital and research committee, and H. C. Goodsil, director of research and education.

FOR years "The Friends of our Native Landscape" have worked for the reservation of the Sayer Bog—a typical tamarack bog—and the only one of its kind in Illinois. A number of bogs have been drained and destroyed, but there are still seven or eight left with an incomplete flora. For students and scientists of this region the Sayer Bog will be of great value, and as a bit of native landscape it is one of the outstanding monuments of its kind of this region. Under the agreement with the present owners—the Pistakee Country Club—the bog is placed under the supervision of the Northwestern University with Dr. Waterman in charge. The agreement further stipulates that the Pistakee Country Club will guard against trespassers and protect the bog from being drained by adjoining neighbors. The owners agree that in case they should desire to dispose of this property Northwestern University will be given the first chance to buy the bog at the original purchase price. Visitors must obtain permission to visit the bog through the Northwestern University.

ACCORDING to information received from Professor Subbotin, of the Tashkent Observatory, a new station for the continuous observation of latitude variations is to be established at Kitab, in Turkestan, on the "International Parallel" (39° 8′ North). In 1899, six stations were established on this parallel by international cooperation. Owing to the war and other causes, three of them have been discontinued, leaving only three in operation at the present time. The new station at Kitab is about three hundred km. east of the former latitude station at Tchardjui, and about 300 km. southwest of the observatory at Tashkent. It will be under the charge of Professor Nefediev.

IN continuation of a program of scientific research in mining and metallurgy conducted jointly by the Carnegie Institute of Technology and the Pittsburgh Station of the U. S. Bureau of Mines, eleven college graduates have been appointed to research fellowships for the coming year. Six of the appointees will conduct their investigations in the field of metallurgy and five will study problems in mining and utilization of fuels. Appointments to mining fellowships were as follows: Harry A. Brown, B.S., chemical engineering, Lehigh University; Raymond C. Johnson, B.S., chemistry, Monmouth College; Harold M. Morris, A.B., chemistry, Cornell College; Robert N. Pollock, B.S., chemistry, and Donald L. Reed, B.S., chemical engineering, University of Washington. Appointments to metallurgical fellowships were: John M. Byrns, B.S.,

metallurgical engineering, Case School of Applied Science; John F. Eckel, A.B., chemistry, University of Kansas; Hyman Freeman, B.S., engineering chemistry, Georgia School of Technology; Frank C. Norris, B.S., chemical engineering, University of Illinois, and Harold E. White, E.M., mining and metallurgy, Lehigh University. The research fellows will begin their work on August 15 for a period of ten months. Two advisory boards, one composed of mining engineers and operators, and the other of metallurgical engineers and steel executives, will assist in selecting the problems for study. Each research fellow will conduct his studies under the direction of a senior investigator from the Bureau of Mines. At the completion of their studies they will be eligible to receive the degree of master of science from the Carnegie Institute of Technology. As in the past, reports of the investigations to be made during the coming college year will be published in bulletin form for public distribution.

UNIVERSITY AND EDUCATIONAL NOTES

BY the will of Randolph McNutt, a furniture dealer of Buffalo, N. Y., Dartmouth College receives the residuary estate, valued at more than $750,000, to be used for general educational purposes.

AN annual appropriation of $10,000 for five years has been given to Princeton University by the Public Service Electric and Gas Company of New Jersey for the advance of "pure scientific research."

THE Burma Oil Company has offered £100,000 to the new Rangoon University, India, for a college of mining and engineering, to be associated with the name of the company.

DR. BARNETT SURE, of the College of Agriculture of the University of Arkansas, has been promoted to a professorship and has been appointed head of the department of agricultural chemistry.

DR. JAMES B. KENDRICK, of the department of botany of Purdue University Agricultural Experiment Station, has been appointed associate professor in the division of plant pathology of the University of California, at the experiment station at Davis, California.

DR. G. L. CLARK, assistant professor of chemistry in the chemical engineering department of the Massachusetts Institute of Technology, will succeed Dr. G. D. Beal next year at the University of Illinois, where he has been appointed associate professor.

S. F. BIBB, of the University of North Dakota, has been appointed professor of mathematics at the Armour Institute of Technology.

DR. I. DE BURGH DALY, lecturer in experimental physiology in the Welsh National School of Medicine of the University of Wales, Cardiff, has been appointed to the chair of physiology in the University of Birmingham to succeed Professor E. Wace Carlier, who has retired.

DISCUSSION AND CORRESPONDENCE

THE STACKABILITY OF TETRAKAIDECAHEDRA

IN the issue of SCIENCE for June 18, 1926, Frederic T. Lewis, in a communication entitled "An Objective Demonstration of the Shape of Cells in Masses," makes the following statement: "Meanwhile Lord Kelvin had found that a fourteen-sided figure—a cube truncated by an octahedron[1]—having six quadrilateral and eight hexagonal surfaces, solves the problem of dividing space without interstices into uniform bodies of minimal surface."

In the issue of SCIENCE for September 3, 1926, John Millis, in a communication under the title, "The Shape of Cells in Masses," begins his paper with the above quotation from the article by Lewis. Millis continues as follows: "The statement is a correct expression of Lord Kelvin's claim as set forth in the somewhat famous Baltimore lectures of several years ago. But the claim is entirely wrong. Having been myself perplexed by so direct and confident an announcement from such an eminent source, let me ask that a definite correction of a serious error be now made in order that others may be saved from being misled and perhaps from consequent mistakes. The volume described, called the tetrakaidecahedron, does not possess the properties as stated. Equal volumes of this pattern will not fit together without voids, as a brief consideration of the dihedral angles or the angles between the faces and the relations of the faces or a practical trial with models would at once have shown."

Such a positive and detailed criticism, pointing out the claimed "error" in Lord Kelvin's equally positive statement, supported by Lewis, might have settled the matter, except that the writer took the suggestion made by Millis in the last sentence quoted above and considered the dihedral angles and even constructed models as advised. If one consider the cross-sectional plane through the center of the volume (passing the sectioning plane perpendicularly through a face of the figure), the resulting section is a hexagon. If we consider the angles in the hexagon we find that they are equal to the corresponding dihedral angles of the volume in question and are as follows:

[1] "The edges of a regular octahedron are trisected. Each vertex of the octahedron is then cut off by a plane passing through the points of trisection adjacent to the vertex. The resulting solid is a regular tetrakaidecahedron."—Graustein.

(1) between quadrilateral and hexagonal
(2) between hexagonal and hexagonal
(3) between hexagonal and quadrilateral
(4) between quadrilateral and hexagonal
(5) between hexagonal and hexagonal
(6) between hexagonal and quadrilateral faces.

It will be seen further that there are two angles of type A (between hexagonal and hexagonal faces) and four angles of type B (between hexagonal and quadrilateral faces) and these angles of the polygon (a hexagon) sum up to 720 degrees. It follows then that:

$$A + 2B = 360 \text{ degrees.}$$

It must be evident that the volume is stackable if the dihedral angles around any and every line at the intersection of planes can be shown to be three in number, one of which is of type A and two of which are of type B. Perhaps at this stage it would be well to heed Millis's advice and construct a model. This can be rather easily done by paper-folding, or by taking a fairly stiff copper wire and a pair of pliers and weaving the desired pattern. It is then quite easily shown that, when stacked, any line of intersection in the mass is at once the side of an equilateral quadrilateral and of two adjacent equilateral hexagons. The dihedral angles are therefore: one of type A (hexagon-hexagon) and two of type B (hexagon-quadrilateral).

It should be pointed out that the octahedron should truncate the cube in such a way that equilateral hexagons result, *i.e.*, all sides of quadrilaterals and hexagons are equal. If this is not done, the 1, 3, 5 sides of a hexagon will not be the same length as the 2, 4, 6 sides. Experimentation will show that in stacking the volumes the 1, 3, 5 sides of a hexagon in one figure must coincide with the 2, 4, 6 sides of a hexagon in a second figure, etc. Obviously, if they are of unequal length, this becomes an impossibility and therein may lie a meager basis for Millis's error.

There is no doubt that the figure mentioned by Lewis is stackable.[2]

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[2] When the letter from Colonel Millis was brought to the attention of Professor W. C. Graustein, he wrote out a brief mathematical demonstration that Lord Kelvin was right; tetrakaidecahedrons are space-filling. Meanwhile Colonel Millis, quite independently, had arrived at the same conclusions. The publication of their letters was not requested. A further treatment of the same subject may be found in the *Bulletin of the Torrey Botanical Club*, 1927, Vol. 54, pp. 341–348.—EDITOR.

EARTHWORMS AND LIGHT

IN a previous note printed in SCIENCE I have mentioned the effect that ordinary light, such as that emitted by a three-celled electric flashlight, has on earthworms. When such a light is thrown at close range on the anterior or pigmented portion of the worm's body it usually causes instant withdrawal of the creature into its burrow. It seems quite possible that sensitivity to light in the earthworms is associated with this pigment, which is of a purplish hue and in sunlight glistens with iridescent color. It occurs most densely on the anterior fourth of the body, which region quite obviously is most sensitive to light.

Recently I have experimented with lights of various colors to determine the reaction of the worms (*Lumbricus terrestris* Linn.), to them and was much interested to discover that light transmitted through a red glass of the sort commonly used for photographic dark-room lamps had no visible effect on them, as apparently they did not perceive it. A 40-watt electric light bulb was used in the red lamp and even when this was brought within four inches of the worms they continued undisturbed in their ordinary occupations of feeding and dragging various objects into their burrows. Quite a different reaction was caused by rays from the opposite end of the spectrum, as when a blue light of a dark shade was flashed upon them they withdrew rapidly to the earth. By use of a suitable red light it is possible to observe accurately the behavior of such worms, and I am publishing this information for the benefit of those investigators who are interested in the problem of the origin of the sounds recently discovered to be emitted by earthworms.

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RESPIRATION OF INSECTS

IN SCIENCE for May 6, 1927, appeared a note under the above title by D. A. MacKay. The general conclusions drawn in this note would not seem to be warranted by the data presented, especially in view of the fact that contrary results have been reported previously.[1] In reference to the idea that in the grasshopper air is alternately inhaled and exhaled through all of the spiracles, the statement is made that "the same thing is probably true of all insects." As a matter of fact in a number of species of insects (the blowfly, Dytiscus and Cybister beetles), in which the mechanics of respiration have been studied, certain spiracles have been shown to be inspiratory and others expiratory.

[1] Lee, M. O., *Jour. Exp. Zool.*, 1925, XLI, 125.

The one experiment described by MacKay which would indicate that the thoracic spiracles serve equally well for inhalation and exhalation, does not seem to be conclusive. In this the head and thorax of a grasshopper were placed under water and the abdomen left out. The bubbles of air which came from around the thorax may have escaped through the injured valve of a spiracle or may have been carried under the water adhering to the waxy chitin. I have made such tests repeatedly on grasshoppers, cockroaches, walking sticks and representatives of every other family of Orthoptera, and have never seen air pumped out of the thoracic spiracles of normal animals. Sometimes when the head and thorax of the insect are thrust under water some air is held around the head and legs. This air may collect as bubbles and float to the surface, and might seem to have come from the spiracles. Also, if the spiracular valves are held or torn open, air bubbles may escape at each contraction of the abdomen. In such an experiment with the head and thorax submerged, the abdominal spiracles which normally open during the collapse and close during the expansion of the abdomen, remain open continuously, evidently serving both for inspiration and expiration. It is true that in such a case the respiratory movements go on and complete asphyxia does not occur. There is, however, some evidence of partial anoxemia in the lessened irritability of the animal.

A few other data bearing on the question might be reviewed briefly. The movements of the valves of the spiracles indicate clearly their actions in inspiration and expiration. The valves of the anterior four pairs of spiracles very plainly open during the inspiratory phase of the cycle (enlargement of the abdominal cavity) and close during the expiratory phase (collapse of the abdomen). The thin, membranous portions of the neck and thorax may be seen to bulge out during each expiration, and this does not occur if the valves of any thoracic spiracles be held open. Further, if the valves of the thoracic spiracles are held open while under water, air bubbles escape at each contraction of the abdomen.

That the abdominal spiracles do not function normally as inspiratory orifices is indicated by the fact that with the abdomen submerged in water, bubbles of air appear over the spiracles and become noticeably larger at each contraction of the abdomen.

The size of the bubble is not noticeably decreased during the expansion of the abdomen, as must surely occur if the abdominal spiracles acted as inspiratory orifices.

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FUNDAMENTALISM IN PHARMACY

PROFESSOR GRIER'S letter in a recent issue of SCIENCE has acquainted the scientific public with the change that has occurred in the management of Des Moines University. The issue of *The Gospel Witness* (a publication in the interest of the American Baptist Bible Union) for July 21 contains an account of the investigation of the faculty of the department of pharmacy at the university as follows:

> Two excellent gentlemen were in charge of the college, but the head was a Unitarian. After meeting him we were not surprised to learn that he was very popular with the students. He is a delightful man, whom we all coveted for the Lord Jesus Christ, but, under the circumstances, it became necessary for the faculty to find a new head for the institution.

HENRY LEFFMANN

QUOTATIONS

EPIDEMIC ENCEPHALITIS IN ENGLAND

THE Minister of Health stated the other day, in a written answer to a question, that during the past five years nearly 5,000 persons have died in England and Wales of epidemic encephalitis, the so-called sleepy sickness. During the same period 11,420 cases of the disease have been notified, so that the melancholy fact emerges that nearly half of all those stricken by epidemic encephalitis in this country have succumbed. The fate of those who have escaped death was not referred to by Mr. Neville Chamberlain, but a long series of researches, extending over the known "history" of the disease, suggests that recovery, in the true meaning of that word, is the exception rather than the rule. Epidemic encephalitis leaves behind it, in the majority of instances, damage to body or to brain of a more or less severe kind. As is well known, it possesses the power of transforming character, and this transformation is nearly always from good to bad. It possesses also the power of inducing that form of paralysis known as "Parkinsonism." So grave a malady merits, without doubt, the close attention of the public, especially since it seems to have become established in this country. The Minister of Health pointed out that there were 2,267 fresh notifications of epidemic encephalitis in 1926, 2,635 fresh notifications in 1925, 5,039 fresh notifications in 1924, 1,025 fresh notifications in 1923, and 454 fresh notifications in 1922. The epidemic wave, which reached its highest point in 1924, has therefore by no means subsided, though it has been reduced in magnitude.

It is a temptation in these circumstances to urge that research work on the unknown origins and

means of transmission of this disease should be extended. In fact, however, suggestions of this kind are not helpful, because a prolonged and special training is necessary before any scientific worker can address himself usefully to the study of epidemic encephalitis. All those who possess the necessary qualifications are at present engaged in one or other of the branches of research which have a bearing on the prevention, causation or treatment of the disease. The public has a duty to see that the work now being carried on is not hampered by any lack of resources, but beyond the discharge of that duty it can not properly intervene. It can, however, and should, insist that the after-care of the victims of the disease shall be undertaken by those best qualified to conduct it. Provision for the care of mental deficiency arising as a consequence of epidemic encephalitis is still woefully inadequate. Moreover, the means are not always available to afford persons convalescent from the disease the prolonged and careful attention which they require. The London County Council deserves all praise for its effort to provide treatment of partially recovered cases, an effort which has already yielded valuable additions to the knowledge about the disease; but this isolated example of public spirit is not enough. As Dr. A. F. Tredgold, speaking on behalf of the People's League of Health, pointed out to the Home Secretary two years ago, it is an urgent necessity to provide an institution where all child victims of epidemic encephalitis, whose minds have been unbalanced, may receive continuous and special treatment. The same idea without doubt informed the statement of the medical officer of Brixton Prison in his report for the year ended March 31, 1925, that "we have had one or two post-encephalitic delinquents who resemble congenital defectives in their mental characteristics. Those cases are, apparently, hopeless, and it is feared that their number will increase unless some method of curing or protecting against (the disease) is discovered."—*The London Times.*

SCIENTIFIC BOOKS

Neuzeitliche Bekämpfung tierischer Schädlinge. By K. ESCHERICH. Berlin. Julius Springer, 1927.

To Dr. K. Escherich, of the University of Munich, more than to any other individual is probably due the revival of interest in economic entomology in Germany and its present high standing. Under the Carnegie grant, and while he still taught forest entomology at the well-known Forest School at Tharandt, he visited the United States in 1911 and made the studies described in his book "Die angewandte Entomologie in den Vereinigten Staaten." On his return to Germany, he was instrumental in founding the German Society for Applied Entomology and was its first president. His entomological work was largely interrupted by the war, as he was brought into the medical service of the army, but on its conclusion he was transferred to the University of Munich and has been promoting actively the purposes of the new society and furthering the cause of economic entomology in every possible way.

He, with some of the other members of the society, started two admirable journals. He has written many papers and delivered many addresses but none of broader scope and more convincingly phrased than the present one which was delivered before the eighty-ninth meeting of the great German Association of Naturalists and Physicians at Düsseldorf in September, 1926, and which has been reprinted the present year from *Die Naturwissenschaft.*

He gives the great war the credit of showing the German people, thrown practically entirely on their own productive resources, that crops are not gathered in proportion to what has been sown and cultivated, but to what has been left over by the insect pests. This is his own expression. Could it be more perfectly put?

As a forest entomologist, it is natural that his illustrations should be drawn from the forest, but the generalizations which he makes apply in many cases to other cultures. While in America he became much interested in the subject of natural control, and he dwelt upon the features of this aspect of economic entomology in his book on his American experiences. Naturally, as a skilled and broad forester, he thinks of the forest as an entity—as a biocoenosis—and considers philosophically the necessary interrelations of the multitudinous organisms that constitute forest life. He draws from these considerations the inevitable conclusion that change of a mixed forest into a one-type forest can not fail to have a most disastrous effect upon certain of the very important elements of the forest's existence; and in working this out he considers especially the interrelations between the destructive insects and their parasites, following out the idea that many of the most important parasites of destructive insects are not specific to one host but have several hosts of differing food plants. Thus, the presence of a certain variety of trees is necessary to insure the supply of some of the most important parasites. The reestablishment of mixed forests to replace monocultures is therefore desirable.

In the course of his address he brings out a number of very interesting points. Under the head of parasites, he suggests the desirability of keeping on hand large quantities of strongly polyphagous species which may be reared easily in large numbers. He

states that Haase has been rearing an egg-parasite of the genus Trichogramma in Petri dishes, where it can readily be secured in very large numbers. It may be mentioned incidentally that the same idea has occurred to American workers and that insects of the same genus are now being reared in this way in California for use against the codling moth, especially in the walnut groves. He treats of the control of insects by diseases, and mentions good results obtained by Schwangart with fungi that destroy the larvae of Cochylis. He also treats of resistant plants and of the desirable qualities of insecticides in general. It is interesting to note that, even before the war, a German forest warden named Zimmerman obtained a patent in Germany on the process of combating insects by means of airplanes, a method which has been developed in this country since the war and which is entering into a promising commercial phase.

The address closes with a strong plea to his audience, which he stated comprised the largest forum of German scientists, to turn their attention toward applied entomology and to assist in manifold ways in the work against injurious insects.

It is a strong paper and quite worthy of Escherich. He realizes that the insect problem is a world problem, and is trying to prove this to the scientific men of Germany.

L. O. HOWARD

PALEONTOLOGICAL AND GEOLOGICAL INVESTIGATIONS IN THE JOHN DAY REGION OF EASTERN OREGON

A COORDINATED program of research, rather unique in the range and the detailed nature of the studies included in it, is being conducted in the John Day region of eastern Oregon. Through investigations in vertebrate and invertebrate paleontology, paleobotany and physical geology, an attempt is being made to construct as completely as possible the history of the development of animal and plant life and of geologic and climatic changes in this part of the northwest in the later eras of geologic time.

President John C. Merriam, of the Carnegie Institution of Washington, is both directing the project and participating actively in the field and laboratory investigations. The studies are an extension of researches initiated in this region by Dr. Merriam more than twenty-five years ago. The program is being prosecuted under the auspices of the Carnegie Institution of Washington; other institutions which have been cooperating are the University of California, the University of Oregon and the California Institute of Technology.

Mammalian fossil remains in important quantities have been collected in the John Day Basin from three formations, of Oligocene, Miocene and Pliocene age. In the thirty-five years beginning in the late sixties quite large collections were made and studied by Condon, Marsh, Cope, Scott, Merriam and Sinclair. In the last quarter-century many others have contributed to our knowledge of these faunas, largely through study of materials gathered in the field during the earlier period. As part of the present program of research notable additions have been made to the fossil material through further collecting; these furnish an adequate basis for a revision of the faunas from the John Day formation and for a better understanding of the mammalian assemblages from the Miocene and the Pliocene Rattlesnake deposits. These faunas are being studied by Dr. Merriam and by Dr. Chester Stock of the California Institute of Technology, and several preliminary reports are either in preparation or have already appeared. In addition to indicating the age and correlation of the formations and aiding in determining the climatic and topographic conditions under which the rocks were deposited, these rather large collections give a vivid picture of the animal life which existed in this region during certain periods of the Cenozoic era.

The paleobotany of the region is being investigated by Dr. R. W. Chaney, research associate of the Carnegie Institution. Large collections of fossil plants have been made and studied, representing the forests and smaller associated plant life of Clarno, John Day, and Mascall time. Results already published contribute to the taxonomy of Tertiary fossil plants, and the ecology of the floras. Important interpretations of the fossil plant assemblages have been made on the basis of the ecologic relationships of certain modern floras. Significant facts regarding the age and the climatic and other conditions of deposition of the formations which contain them have been brought to light.

The invertebrate paleontology of eastern Oregon, especially of the older horizons lying beneath the Tertiary continental deposits, is being studied by Dr. E. L. Packard, of the University of Oregon, who has secured excellent collections of cephalopods and other marine invertebrates. Numerous new forms have been recognized in these faunas, and are being described. The last invasion of the sea into eastern Oregon occurred apparently in Chico Cretaceous time, and Dr. Packard is attempting to ascertain from these isolated strata—the only Pacific Cretaceous exposed east of the Cascades—something of the position of the Cretaceous shorelines and the topography and climate of the adjacent land masses. Pre-Cretaceous horizons bearing faunas probably not recognized here-

tofore in eastern Oregon have also been discovered and are being studied.

Dr. Merriam published an excellent summary of the physical geology of the John Day region in 1901. No detailed mapping of the geology had been done, however, before the present program was initiated. The region is a key area for the whole northern Great Basin Province in that a larger number of post-Jurassic formations is exposed here than at any other locality. In no other district are the great Columbia lava fields dissected so as to expose earlier Tertiary formations so extensively.

To facilitate geologic mapping the U. S. Geological Survey, under a cooperative arrangement with the Carnegie Institution, has made topographic maps of two areas: the Mitchell Quadrangle of about 750 square miles, and the Picture Gorge Special Quadrangle of about 56 square miles (on large scale). The writer has finished the geologic mapping of the latter area and has nearly completed the Mitchell Quadrangle. The areal and structural studies are as detailed as the scales of the two maps permit.

The formations exposed are: a pre-Cretaceous crystalline complex; Chico, upper Cretaceous; Clarno, Eocene or Oligocene; John Day, upper Oligocene; Columbia lavas, middle or upper Miocene; Mascall, middle or upper Miocene; and Rattlesnake, Pliocene. All the contacts excepting the Columbia lava-Mascall and perhaps the Clarno-John Day are very striking nonconformities. Both an exceedingly eventful geologic history and a very interesting series of gemorphic changes are evidenced by the results of the mapping.

The investigations in all phases of the John Day program are being continued during the summer of 1927.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE STUDY OF RHIZOPUS IN THE GENERAL COURSE OF BOTANY

IN many botanical laboratory courses it is the custom to study bread mold as a mass of hyphae covering bread or some other medium and to mount some of the mycelial mass on a glass slide, teasing it out for further observation of the vegetative structure. This method has seemed unsatisfactory, and I wish to suggest another method which has been used with success in the course in general botany at Macalester College.

Between two glass slides (5 cm. × 11½ cm.) are placed several layers of filter-paper of the same size as the glass slides, the interior portions of which have been cut out so as to form a border of filter paper about one centimeter wide. A small piece (2 or 3 cu. mm.) of the moist bread on which the culture is growing is placed between the glass slides in the center of the band of filter-paper. The slides are then tied together with thread, the filter-paper moistened by dipping the edges of the slides in water and the whole mount placed under a bell-jar. In about two or three days the stolonifers will extend outward in various directions from the moist bread, and wherever they come in contact with the glass surface rhizoid-like hyphae and sporangiophores are produced. This may now be studied either with the compound microscope or with the binocular microscope.

This enables the student to trace the stolonifers with ease from their origin to their attachments to the glass and to study the sporangiophores and rhizoid-like hyphae in their natural positions without any disturbance of the hyphae or any danger of their drying during the study.

The above described damp chamber is practically the same as that used by Dr. R. E. Jeffs in his studies of root-hair elongation and described in the *American Journal of Botany* 12: 577–606, 1925.

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SPECIAL ARTICLES

THE VARIABILITY OF LONG DIFFRACTION SPACINGS IN PARAFFIN WAXES

So much interest is being manifested in the polymorphism of long chain compounds, particularly the fatty acids (Piper, Malkin and Austin, *J. Chem. Soc.* 1926, 2310; deBoer, *Nature,* 119, 50, 635 (1927); Thibaud, *Compt. rend.* 184, 24, 96 (1927); Müller, *Proc. Roy. Soc.* 114-A, 542 (1927), that it seems advisable to report the results of some X-ray experiments with ordinary commercial paraffin waxes. Only one mention of X-ray studies of these complex mixtures of many hydrocarbons has been made, that of Piper, Brown and Dyment (*J. Chem. Soc.* 127, 2194 (1925) who found that the lines of the C_{28} hydrocarbon appeared alone for a paraffin wax although this fraction furnished only 16 per cent. of the mixture and other members as high as C_{32} were probably present.

In the present investigation samples were prepared from waxes melting at 135, 130, 125 and 120° F. by solidifying on glass plates and photographing in an oscillating spectrograph with copper Kα rays.

Solidification took place under identical conditions, since cooling from above the melting points to just below occupied 30 minutes. Remarkably sharp lines for 3 orders only were obtained corresponding to single long spacings, besides the "side spacing" lines. These were all measured with greatest care and checked against photometric curves. The results are as follows:

Wax m.p.	d_1	No. C atoms indicated	d_2	Side spacings d_3	d_4
135°F.	39.42A.U.	29.0	4.24A.U.	3.73A.U.	2.56A.U.
130°	38.58	28.5	4.17	3.73	2.51
125°	35.22	26.0	4.44	3.88	2.44
120°	34.38	25.0	4.23	3.93	2.33

Particular care was taken in the measurement of the side spacings in order to discover any possible regularity in the slight variations running parallel with the change in the principal spacing. These were further studied with pinhole diagrams and molybdenum Kα radiation. There is apparently no such regularity.

Some experiments demonstrated that the rate of cooling of the liquid wax film was a determining factor in the spacings. The 135° wax was studied further in this respect with the following results:

Cooling	d_1	d_2	d_3	d_4
Instantaneous	36.64A.U.	4.12A.U.	3.82A.U.	2.58A.U.
2 min.	37.84	4.16	3.82	2.60
10 min.	38.24	4.21	3.86	2.63
30 min.	39.42	4.24	3.73	2.56
60 min.	40.20	4.13	3.82	2.60

It is evident that the longer the time given the molecules for orientation the greater the spacing for the *same* wax.

The presence of addition agents in small amounts also affects the spacings, when the solidification conditions are kept constant, as shown by the following results on 135° wax with cooling during 10 minutes:

	d_1
Wax alone	38.24 A.U.
" +1 per cent. α-naphthylamine	38.315
" +1 " " diphenyl oxide	39.75
" +0.5 " " indigo	40.70
" +1 " " Pb oleate	37.5

It is interesting to note that the translucency of the films measured with a Martin polarizing photometer varied directly with the spacings, a property of practical importance in the manufacture of transparent waxed paper. The single exception is the wax containing soap. Lead oleate itself has a spacing of 37.5 A.U. and when added to paraffin wax, even in so small amount as 1 per cent., seems to impress its own spacing upon the layers. It is still a matter of astonishment, not only that the principal spacing of a paraffin wax may be varied within limits almost at will, but also that these mixtures of as many as 18 hydrocarbons with widely differing molecular lengths form equidistant parallel diffracting layers at all. The explanation of the variability of the long spacing for the same wax is complicated by the fact that under different conditions different molecular lengths in the mixture predominate and also varying tilts of the molecules to the diffracting layers are possible.

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CROPS NATURALLY INFECTED WITH SUGAR BEET CURLY-TOP

CURLY-TOP of sugar beets, transmitted by the beet leafhopper (*Eutettix tenella* Baker), has caused enormous losses to farmers and beet-sugar companies in the western part of the United States. In California and other western states many beet-sugar factories have been dismantled and moved out of the state, while other mills have been closed permanently or have remained idle during disastrous outbreaks of the disease. Unless efficient parasites of the beet leafhopper can be imported and established or a beet resistant to curly-top can be developed, the industry in many localities of the western part of the United States will perish.

In years when a severe outbreak of sugar-beet curly-top occurs, other crops are seriously damaged by the same disease. During the outbreak of the beet leafhopper in 1919 in California, cantaloupes were a failure in the San Joaquin Valley. During the past two years cantaloupes have been demonstrated to be naturally infected with curly-top in the Salinas Valley, and the symptoms resembled those observed in the San Joaquin Valley in 1919. Spinach was also found to be naturally infected in 1919, and in many localities in later years.

A simple method was adopted in testing plants to determine whether they had been naturally infected.

Leafhoppers which had been non-infective for many generations were fed on stunted diseased plants removed from the field and were then transferred to sugar beets. If the beet developed curly-top it was evident that the original plants had been naturally infected with the disease. Cross inoculations with non-infective insects fed on healthy crops or weeds grown from seeds or apparently healthy crops or weeds removed from the field failed to transmit the disease.

During the outbreak of the beet leafhopper in Idaho in 1924, a disastrous epidemic disease of beans occurred in Twin Falls County. Carsner[1] came to the conclusion on circumstantial evidence that the beet leafhopper may have transmitted curly-top to beans, although he did not see the disease in the field. I have demonstrated by the method described above, that a large number of field and garden beans growing in California are naturally infected with, and susceptible to curly-top.

During the outbreak of the beet leafhopper in California in 1925, squashes and pumpkins were also proved to be naturally infected with curly-top. In 1926, McKay and Dykstra,[2] of the Oregon Agricultural Experiment Station, found curly-top of squash occurring severely in many places in Oregon, Washington and Idaho, resulting in a general failure of squash in the northwest.

It has been known for a long time in California that curly-top of sugar beets and western yellow blight of tomatoes show some correlations. In 1919 and 1925, curly-top destroyed most of the late plantings of sugar beets and seriously reduced the tonnage of early plantings in the San Joaquin and Sacramento Valleys, and interior regions of the Salinas Valley; in the same years western yellow blight of tomatoes destroyed most of the crop in the same valleys. Both diseases are subject to regional variations, being more severe in the natural breeding areas of the beat leafhopper in the San Joaquin and Salinas Valleys than in the coastal regions.

During 1925 and 1926, non-infective beet leafhoppers after feeding on tomato plants affected with western yellow blight transmitted curly-top to sugar beets. Curly-top was also transmitted from tomatoes showing symptoms only of mosaic; this transmission to beets demonstrated that the tomatoes were also naturally infected with the causal agent of curly-top.

Recently McKay and Dykstra[3] came to the conclusion on the basis of circumstantial evidence that western yellow blight of tomatoes is caused by the virus of sugar beet curly-top. They state that typical symptoms of western yellow blight developed in the greenhouse by infecting tomatoes by means of the beet leafhopper.

The following crops have been found to be naturally infected with curly-top in California:

CHENOPODIACEAE, GOOSEFOOT OR SALTBUSH FAMILY

Sugar Beet (*Beta vulgaris*).

Beta maritima.

Mangel Wurzel or Stock Beets (*B. vulgaris*): Giant Yellow; Golden Tankard; Half Sugar; Mammoth Long Red; Red Eckendorf; Yellow Eckendorf and Sludstrup.

Garden, Table or Red Beets (*B. vulgaris*).

Swiss Chard (*B. vulgaris cicla*).

Spinach (*Spinacia oleracea*): Bloomsdale Savoy.

LEGUMINOSAE, PEA FAMILY

Field and Garden Beans: Bountiful, Cranberry, Kentucky Wonder, Long Red Kidney, Small White, Stringless Green Pod, White Seeded Kentucky Wonder (*Phaseolus vulgaris*); Baby Lima or Henderson Bush (*P. lunatus*) and Blackeye (*Vigna sinensis*).

Alfalfa (*Medicago sativa*): Hairy Peruvian.

CUCURBITACEAE, GOURD FAMILY

Pumpkins and Squashes: White Scallop, Summer Crookneck, Delicata (*Cucurbita pepo*): Chicago Warted Hubbard (*C. maxima*): Winter Crookneck and Banana (*C. moschata*).

Watermelon (*Citrullus vulgaris*): Klondyke and Excell.

Cucumber (*Cucumis sativus*): Early Fortune, Long Green and a variety either Chicago Pickle or Long Green.

Muskmelon (*C. melo reticulatus*): Green Nutmeg, Pollock and Tip Top.

Cantaloupe (*C. melo cantalupensis*): Salmon Tint.

SOLANACEAE, NIGHTSHADE FAMILY

Potato (*Solanum tuberosum*): Unknown variety.

Tomatoes (*Lycopersicon esculentum*): (Curly-top was transmitted to sugar beets from tomatoes affected with western yellow blight and mosaic).

Peppers: Anaheim Chili (*Capsicum frutescens*); Paprika (*C. annuum*); Pimento (*C. annuum, C. annuum perfecto*) and Mexican Chili (*C. frutescens*).

CRUCIFERAE, MUSTARD FAMILY, CRUCIFERS

Horse-radish (*Armoracia rusticana*).

Radish (*Raphanus sativus*): Variety questionable, probably Red Globe.

Garden Cabbage (*Brassica oleracea capitata*): Unknown variety.

Turnip (*B. rapa*): Purple Top Globe.

UMBELLIFERAE, PARSLEY FAMILY

Plain Parsley (*Petroselinum hortense*).

HENRY H. P. SEVERIN

[1] *Jour. Agr. Res.*, 33: 345–348, 1926.

[2] *Phytopath.*, 17: 39, 1927.

[3] *Phytopath.*, 17: 48–49, 1927.